

Federal Utilities Partnership Working Group
November 29, 2007

Spectrally Enhanced Lighting

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Spectrally Enhanced Lighting

Spectrally Enhanced Lighting

- This is not a technology; just a different way to quantify light based on well established scientific findings
- Can be used in conjunction with ANY type of lighting design to gain additional energy savings
- Simple to implement, just need a few jobs to experience the results

Spectrally Enhanced Lighting

Why Spectrally Enhanced Lighting?

- Most cost effective way to get quick energy savings
- Non-proprietary
- Requires no fancy controls or gadgets
- Energy savings are significant and provide large portion of federal target energy savings
- WIN – WIN: Low risk, high reward

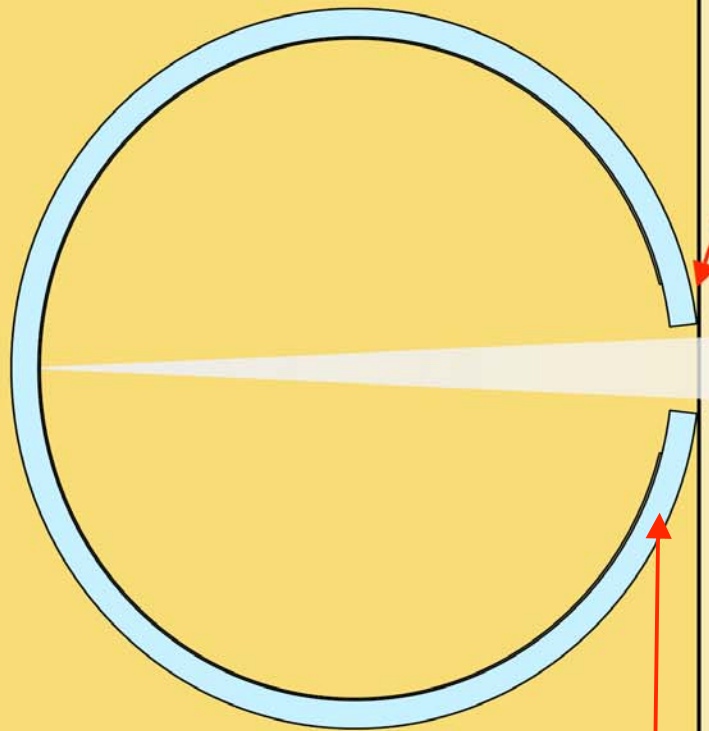
Spectrally Enhanced Lighting

AfterImage

+ space



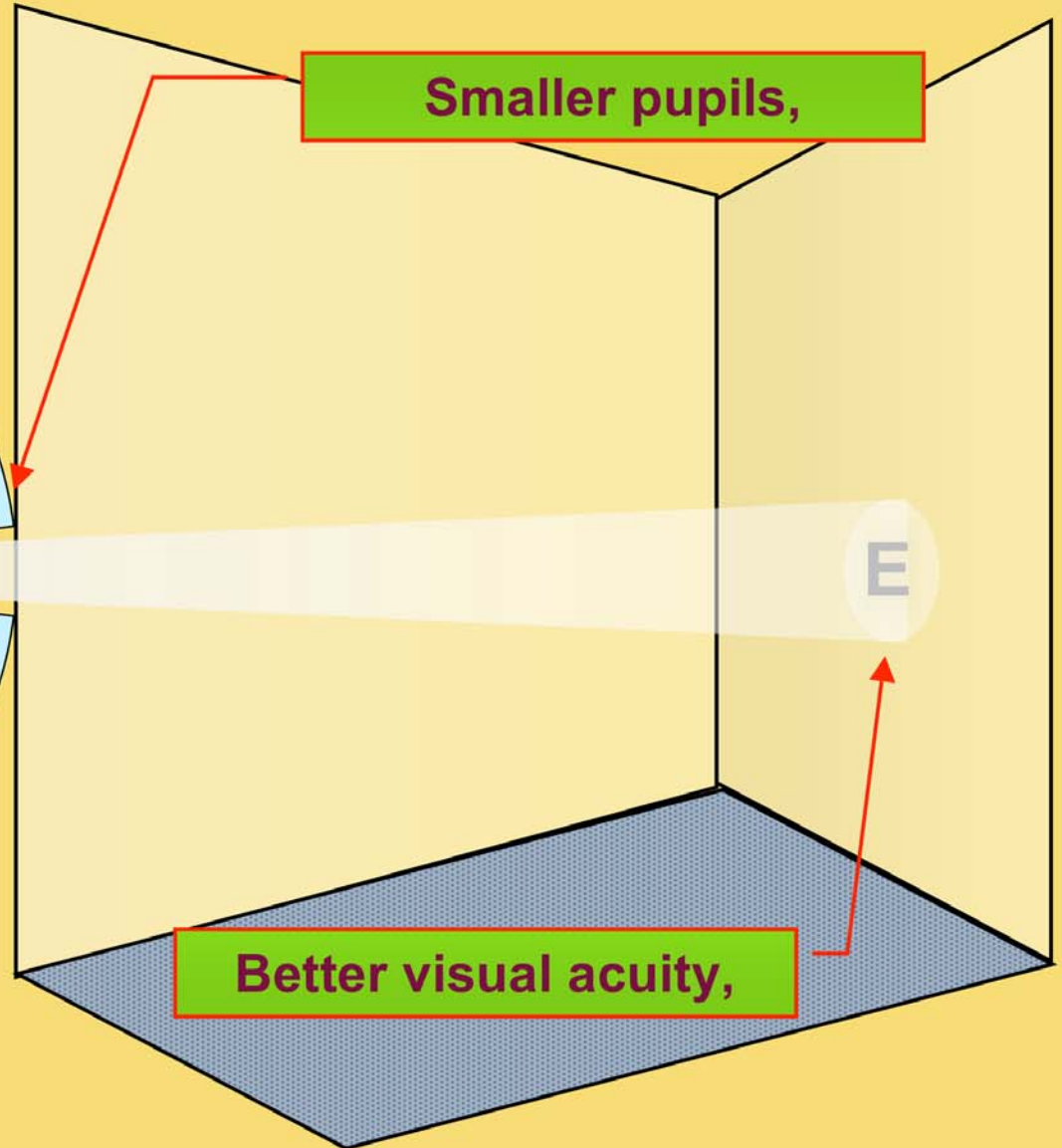
And increased brightness perception



Peripheral photoreceptors are more highly activated, leading to...

Smaller pupils,

Better visual acuity,





Light Source

Shift Spectrum Toward Blue

Spectrally
Enhanced Lighting:
Conceptual Model

Enhances Visual Response

Smaller Pupils

Increased Visual Acuity

Increased Brightness Perception

Reduce Light Level → **Save Energy**

Equal Visual Acuity

Equal Brightness Perception

History of Spectrally Enhanced Lighting

- 1987-1997: Human Physiological Science and Discovery, LBNL
- 2002- Present: Applied Principles and Field Studies, AfterImage + Space:
 - Field Tests of Lab Studies
 - Determine whether formulas work
 - Assess occupant reaction to high color temperature lighting

History of Spectrally Enhanced Lighting

Recent Field Studies

● 2002-2004: UCOP

- Tested for occupant acceptance under the conditions of reduced illuminance per the laboratory method
- Found Occupant Acceptance

● 2004-2006: Economics Validation

- Assess Economics with fixed output ballasts
- Validated cost effectiveness, energy savings, occupant satisfaction, task lighting usage, and the Visual Effectiveness Calculations

2005-2006 Study

AfterImage

+space

3 Buildings
Selected...

Building A
(735, T12)



Building B
(730, T8)



Building C
(741, T8)



Similarities of Pre-Retrofit Conditions:

- Parabolic Luminaires
- Mixed Private & Open Offices
- Mixed Daylit & non-Daylit Areas
- Over 100 Full-time Workers

Differences of Pre-Retrofit Conditions:

- Lamp Color
- Lamp & Ballast Technology
- Energy Savings Potential

2005-2006 Study

Findings

- Nearly 50% energy savings on T12 conversion
- 20% energy savings on T8 conversions
- NO increase in task lighting usage
- NO difference in occupant satisfaction

The math behind Spectrally Enhanced Lighting works, and building occupants are equally satisfied with the new color of light.

Spectrally Enhanced Lighting - Progress

Spectrally Enhanced Lighting has a long track record and is ready to be Deployed



In 4 Short Years, S.E.L. has been taken from the lab to reality:

- Mathematical Models Tested and Validated
- Occupant Satisfaction & Economics Demonstrated
- California Incentive Program Launched
- FEMP Buildings Initiative Started

Spectrally Enhanced Lighting

The (not so secret) Weapon:

- 850 lamps:
 - 5000K Correlated Color Temperature (CCT)
 - 82-85 CRI
- Use in combination with any ballast to make these two conditions equal:

$$P_{\text{existing}} \times \left(\frac{S/P}{(S/P)_{\text{existing}}} \right)^{.78} = P_{850} \times (S/P_{850})^{.78}$$

Where P = light levels in footcandles

(S/P) = the S/P ratio of the lamps

S.E.L. Energy Savings

S.E.L.: Increased Efficiency and Energy Savings

Lamp	Mean Lumens (Catalog)	S/P Value	Equiv. Visual Efficacy	Energy Savings
850 3 rd	2860	1.95	4815	
F32T8 730	2650	1.19	3035	37%
F32T8 735	2650	1.3	3252	32%
F32T8 830 2 nd	2800	1.29	3415	29%
F32T8 830 3 rd	2950	1.29	3598	25%
F32T8 835 2 nd	2800	1.41	3661	24%
F32T8 741	2650	1.56	3749	22%
F32T8 835 3 rd	2950	1.41	3857	20%
F32T8 841 2 nd	2800	1.62	4079	15%
F32T8 841 3 rd	2950	1.62	4298	11%

Energy savings are significant compared to commonly used T8 Lamps, even assuming same ballast efficiency...

S.E.L. Energy Savings

S.E.L. Retrofits + New Ballasts = Success!

Lamp	Ballast Tech	EOL Lumen Maint	EOL Efficacy	Energy Savings
850 3rd	EE IS	92%	145	
F34T12WW	Mag RS	78%	45	69%
F34T12CW	Mag RS	78%	60	59%
F32T8 730	SE IS	90%	82	44%
F32T8 735	SE IS	90%	88	40%
F32T8 830 2nd	SE IS	92%	94	35%
F32T8 830 3rd	SE IS	92%	99	32%
F32T8 835 2nd	SE IS	92%	101	31%
F32T8 741	SE IS	90%	101	30%
F32T8 835 3rd	SE IS	92%	106	27%
F32T8 841 2nd	SE IS	92%	113	23%
F32T8 841 3rd	SE IS	92%	119	18%

Optimum energy savings come through S.E.L. and new extra efficient electronic ballasts.

40% Energy savings from traditional 735 lamps!

S.E.L and Tax Incentive

Space Type	Existing LPD's & S.E.L.		Max Tax Incentive	
	US Lighting Market Characterization 2001		ASHRAE 90.1 - 2001	
	Existing	S.E.L.	Code	Max. tax incentive - 40%
Office	1.8	0.8	1.3	0.8
Warehouse/Storage	1.4	0.6	1.2	0.7
Education	1.8	0.9	1.5	0.9
Service	1.7	0.9	1.5	0.9
Public Assembly	1.4	0.8	1.4	0.8
Health Care	1.7	0.8	1.6	1.0
Retail	1.9	1.2	1.9	1.1
Public Order	1.3	0.8	1.3	0.8
Food Sales	1.9	1.1	1.8	1.1

S.E.L and Extra Efficient Electronic Ballasts will achieve 100% of the tax incentive targeted values in most installations!

S.E.L. Potential Demand Savings

Potential Savings:

HUGE

		S.E.L Savings (GW)			Power Plants Saved (300MW each)
		Commercial	Industrial	Commercial + Industrial	
Market Penetration	4%	1.8	0.3	2.1	7
	5%	2.3	0.4	2.7	9
	6%	2.8	0.4	3.2	11
	8%	3.7	0.6	4.3	14
	10%	4.6	0.7	5.3	18
	15%	6.9	1.1	8.0	27
	20%	9.2	1.5	10.7	36
	30%	13.8	2.2	16.0	53
	50%	23.0	3.7	26.6	89
	100%	45.9	7.4	53.3	178

S.E.L Energy Savings Benefits

S.E.L. Retrofits add Benefit to Buildings:

- Energy savings from fluorescents
- Retrofits open door for other efficiency measures:
 - Incandescent lighting to CFL's
 - HID's to Fluorescents
 - Exit signs to LED's
 - Occupancy sensors/timers to turn lights OFF
- Simple, cost effective installations; no complicated controls or experimental products required!
- Maintain occupant satisfaction and visual ability
- All measures add significant life to system and lower maintenance costs.

S.E.L Other Benefits

Current Status and Ongoing Research:

- IESNA has now convened a committee to discuss how they will incorporate this work in the IESNA Handbook - Brian Liebel is Chair of this committee.
- The photoreceptors that have this spectral response controlling pupil size are also responsible for the production of melanopsin that affects circadian rhythm: new research indicates that this may help night shift workers stay alert.
- Our research continues and indicates that the use of SEL can reduce visual effort for reading tasks.

The S.E.L. 850 Lamp – ^{who} who's using it?

Companies/Institutions using 850 lamps:

- Pacific Gas & Electric Company
- San Diego Unified School District
- Cities of San Diego and Oakland
- Counties of Napa and San Mateo
- Port Hueneme

All these have adopted S.E.L. 5000K lighting as their standard for retrofits and new construction

Spectrally Enhanced Lighting

How do you do it???

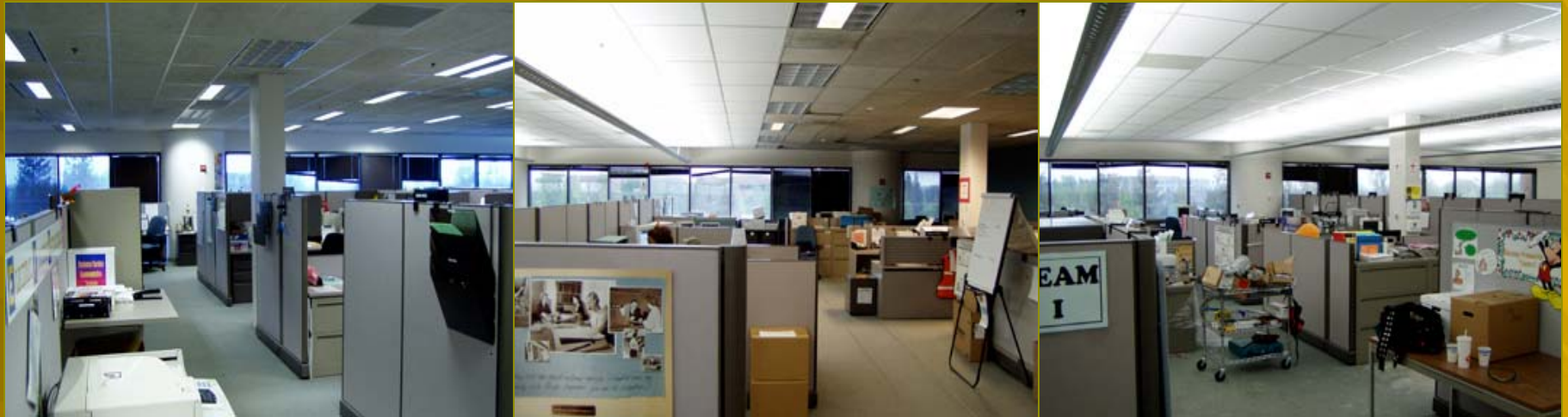
- It's easy after the first few projects; there are a few steps to take to ensure proper installations and occupant acceptance.
- It's important to get the math right – if you're too timid, people will complain that it's too bright.
- Calculations should be performed to ensure that the resulting light levels meet IESNA recommendations.

Spectrally Enhanced Lighting

General Guidelines:

- Lensed fixtures and industrial fluorescents – de-lamp & go to Premium electronic ballasts
- HID's – go to High Performance T8 lamps & Premium electronic ballasts
- Parabolics – toughest because it's hard to reduce the wattage enough in some cases:
 - Go to retrofit kits to de-lamp / improve quality
 - Investigate converting to indirect pendants

Parabolic to Indirect/Direct Conversion



Before

During

After

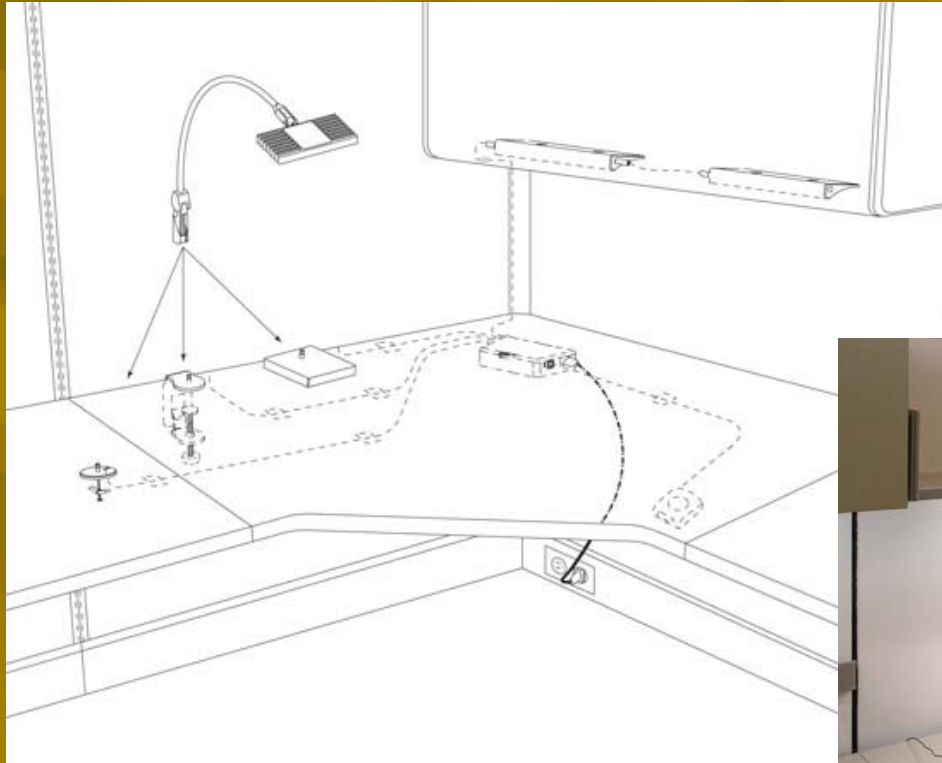
This conversion resulted in Lighting Power Density of .5 Watts per Sq. Ft.!

Occupancy Sensors

Occupancy Sensors:

- NEMA report shows Energy Savings of:
 - Break Rooms - 8%
 - Classroom - 31%
 - Conference Room - 28%
 - Private Office - 20%
 - Restroom - 17%
- These savings based on 20 minute time delay.

LED Task Lighting



Localized System w/
Occupancy Sensor

Undercabinet = 9W
Portable Task = 9W



At this point,
task lighting
holds the
most promise
for LED's in
widespread
applications
for energy
savings.

Summary

- Optimum energy savings are achievable through using a Task/Ambient lighting approach with Spectrally Enhanced Lighting and Premium Electronic ballasts.
- Simple Occupancy Sensors provide additional energy savings, particularly in private offices and intermittently used spaces.
- New Task Lighting fixtures using LED's are here and promise significant energy savings for task lighting applications

Let's Build a Program!

Example:

100,000 square feet of open office space:

- Assume 1.1 W/Sq. Ft. = 110,000 W
 - SEL/Premium Ballast savings = 40%
 - LED Task Lighting savings = .11 W/Sq. Ft.
- New Total = .55 W/sq. Ft. = 55,000 W
- Savings = 50%:

ALL PEAK DEMAND SAVINGS!

Let's Build a Program!

Building Blocks:

- Spectrally Enhanced Lighting +
- Premium Ballasts/Lamps +
- Optimized Retrofit Design +
- LED Task Lighting +
- Occupancy Sensors

.55 W/Sq. Ft.

Let's Build a Program!

The California Model: Leadership in Energy Conservation

- The new target of **.55 W/Sq. Ft.** is obtainable through easily implemented measures, using
- Established and proven technologies, and
- No high-cost control systems or interfaces

We stand ready to work with California Utilities to form a partnership to work toward this goal.

Conclusions

Your Questions and Comments are
welcome!

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